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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report documents the results of the first phase of an investigation into the nuclear effects on military troop performance. Both signs and symptoms associated with radiation sickness were examined to develop models of human response to radiation as a function of dose, time and symptom severity. Data on the early symptomatic effects of radiation exposure were gathered from some 150 books, articles and monographs. The analysis of this data focused on human data collected from the victims of nuclear accidents and		

20. ABSTRACT (continued)

therapy patients. Data from the survivors of the Japanese atomic bombs were excluded because of data imprecision and questions raised about the accuracy of reported exposure levels. A hypothetical exposed population was divided into response groups based on the sensitivity of individuals to radiation: hyper-, hypo-, and normsensitives. The population was also classified by the severity of their symptoms; unaffected and mildly, moderately and severely affected. Using this data, relationships for the onset time and duration of acute symptoms after a given radiation dose were developed.

Conceptual models were then derived for (1) individual response as a function of dose, time after exposure, and severity of symptoms, (2) population response (percentage affected in various degrees), and (3) links between individual and population responses. To develop these models further for the second phase, a better understanding of the relation between acute radiation exposure and subsequent illness as a function of time as well as more data from noninvasive studies of therapy patients is needed. Once the connection between radiation exposure and sickness is sufficiently well understood, it should be possible to make more definitive statements about how human performance will be affected by radiation.

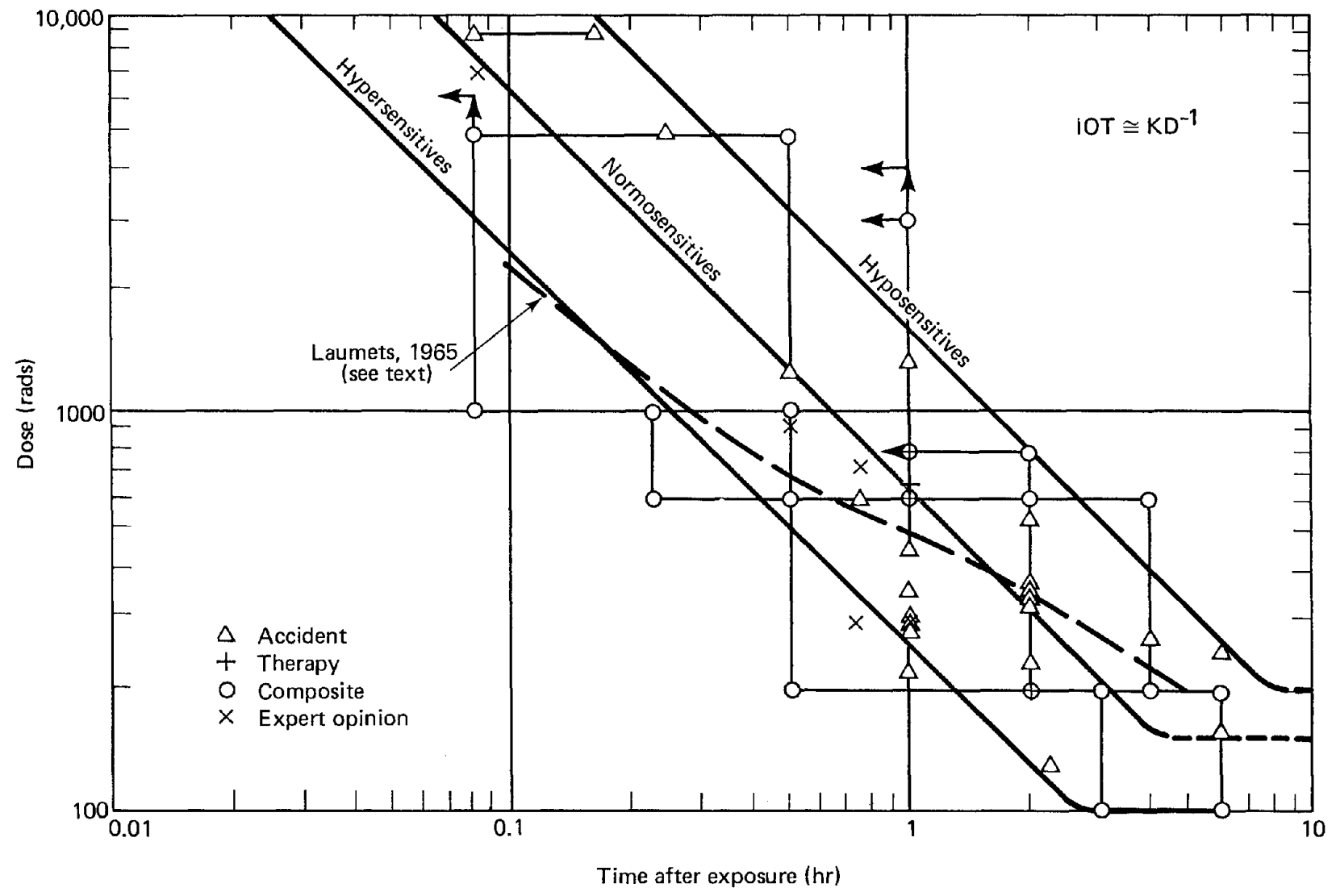


Figure 3. Onset of initial symptoms.

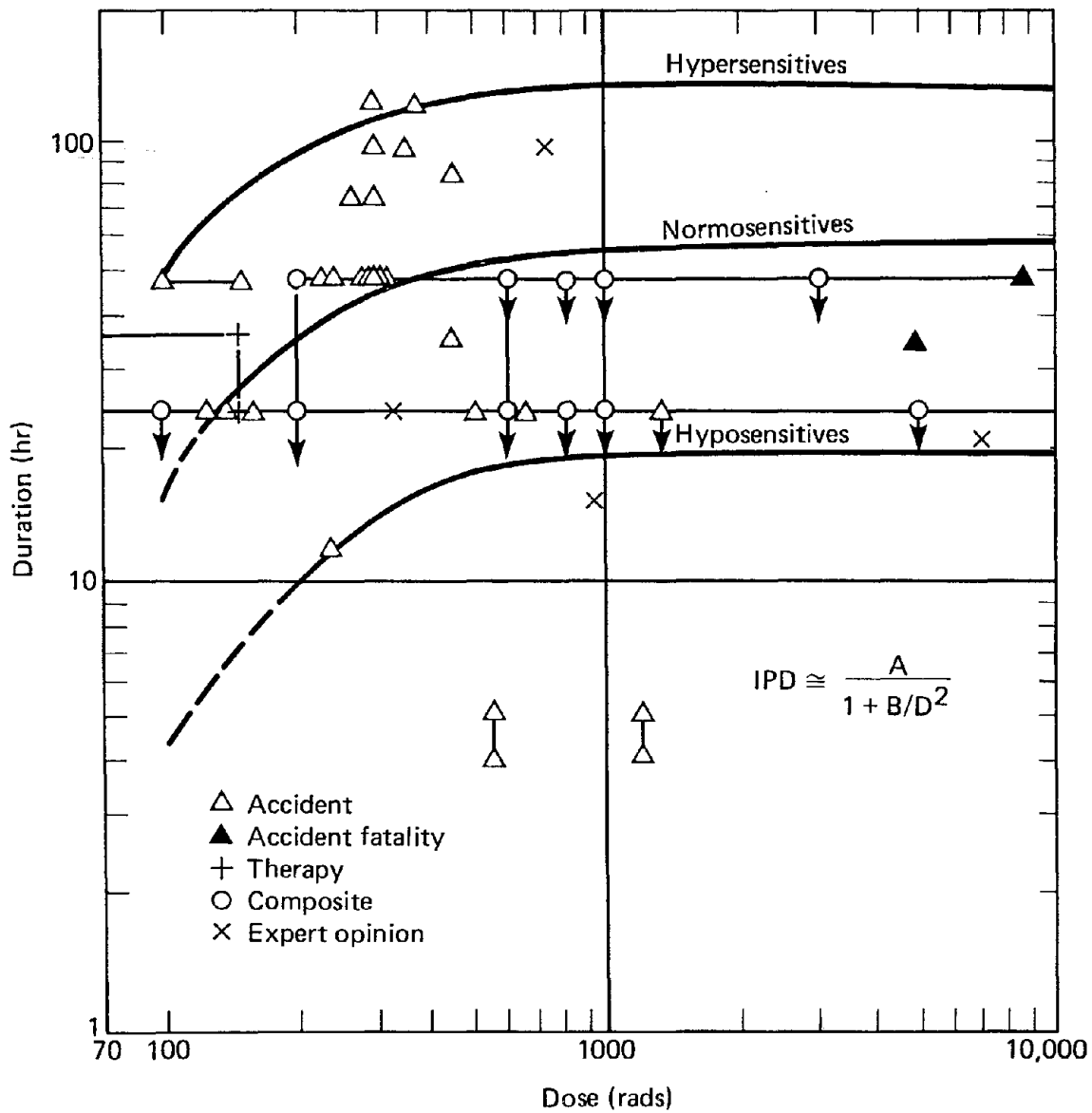


Figure 4. Initial period.

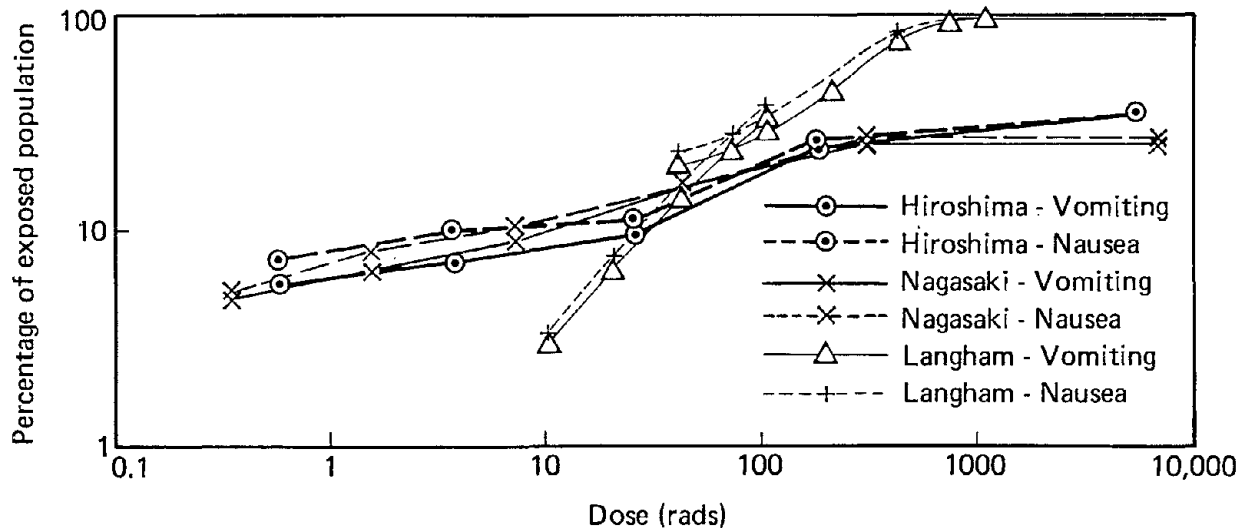


Figure A.3. Nausea and vomiting in atom bomb survivors (Hiroshima, Nagasaki) versus therapy patients and accident victims (Langham).

But the Japanese data differ markedly from the Langham data. At higher doses (more than 100 rads), the therapy and accident data suggest a more severe response than do the Japanese data; at lower doses the therapy and accident data suggest a lighter response. Since our investigation focuses on doses over 100 rads, how might we account for the differences in the two data sources at the higher doses?

One could hypothesize that the Japanese response appears lighter because most victims in rings 1 and 2 (blast center to 1.5 km) were exposed to the lowest doses recorded for the ring. Such an occurrence would lower the averages on which Fig. A.3 is based. However, Fig. A.1 suggests that for Hiroshima the lowest dose in ring 1 was ~ 400 rads, and that in ring 2 was ~ 50 rads. In Nagasaki, Fig. A.2, the corresponding lower limits were ~ 650 rads (ring 1) and ~ 90 rads (ring 2). Those doses are high enough to expect the Japanese responses to be much closer to those shown in the therapy and accident data.

Another possible explanation might be that many Japanese victims were shielded from the full effects of the free-in-air doses shown in Figs. A.1 and A.2. However, Oughterson et al. [1955] report that only 21 out of 1874 persons in Hiroshima, rings 1 and 2, were in bomb shelters or tunnels (in Nagasaki, 145 out of 2671). The rest in both cities were either outdoors or in Japanese types of structure, which afford relatively poor radiation shielding [Auxier, 1977].

It might also be postulated that those who gathered the Japanese data were dealing with a biased sample. Persons surviving after 20 days could represent the "healthier" or hyposensitive portion of the population; the majority might have been too sick to give an account of their illness and were overlooked in the study. The material reviewed offers no means of investigating that hypothesis.

The uncertainties surrounding the discrepancies manifested in Fig. A.3, plus more fundamental questions recently raised about the accuracy of the radiation levels particularly in Hiroshima [Marshall, 1981] persuaded us to exclude the Japanese atom bomb data from consideration in our Sec. 3 response model.